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BIOLOGICAL CONTROL IN WESTERN AUSTRALIA.

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CONTENTS.

INTRODUCTION.

No method of combating pests has appealed so generally to the popular fancy as that usually known as biological control. This is readily understandable for it involves the use of one creature to subject another and reduces to a minimum all manual labour. Despite their general appeal, the principles

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of biological control are by no means generally understood, and the very popularity of the method sometimes leads to the appearance of the most extravagant claims or unreasonable criticisms.

Many of the most outstanding successes with biological control have been achieved under insular conditions. The Hawaiian Islands are probably the best examples followed by Fiji and New Zealand.

Where pests have become widely established on a continental land mass, the chances of successfully introducing parasites are seriously limited. The new environment presents such a complex of factors to be contended with, biotic, climatic and physiographic, that no single parasite or predator is likely to be of more than local significance. This does not mean that successes have not been achieved on large land masses such as America and Australia, but in these instances, the introductions have been made into areas which may be regarded as distinct ecological entities. South Western Australia is generally recognised as an ecological island and possessing a warm equable climate and a certain degree of physiographic isolation, it conforms with the main requirements necessary for the successful establishment of parasites.

The first definite experiment along the lines of biological control is reported to have been made in 1873 (Imms. 1937) when Planchon and Riley introduced an American predatory mite (*Tyroglyphus phylloxeræ* Riley) into France to try and combat the growing menace of *Phylloxera vitifoliæ* in French vineyards.

Parasite introduction received its first real stimulus from the subjugation of the Cottony-cushion scale (*Icerya purchasi*) following the mission of A. Koebele to Australia and the transference to the United States of the ladybird *Rodolia cardinalis*.

The appointment in 1901 of George Compere (Essig. 1931) to collect parasites and make investigations into problems of biological control on behalf of the Western Australian Government, marks the commencement of a period of very active local interest in this branch of insect control and one which has been keenly maintained up to the present day. In 1904 it was arranged for Compere to collect jointly for the Californian and West Australian Governments and his services were retained until 1910 when he returned to California.

Prior to Compere's appointment, however, several attempts had been made to acclimatise useful insects. As early as 1895 (Anon 1895) it was suggested that local parasites and predators be exchanged for insects to control woolly aphis, cabbage aphis and coccids and the first local introduction was the ladybird *Leis conformis* by Claude Fuller in 1896 (Anon 1901). Compere spent much of his time travelling and collecting, his specimens being forwarded to Newman at the West Australian Department of Agriculture for breeding and distribution. Surprising as it may seem the early exponents of biological control did not receive general commendation and in some instances were the subject of ill-conceived abuse. The late W. W. Froggatt (1909) rather bitterly attacked some of Compere's work and strongly refuted many of the claims made on behalf of biological control.

The ensuing pages comprise an account of the various attempts at parasite and predator introduction into Western Australia.

The information has been gleaned from all possible sources including many unpublished manuscripts. Where possible the information given in these early

records has been checked by reference to subsequent literature and specimens in various collections. In many cases, however, the original meagre statements cannot in any way be amplified.

Unsatisfactory as such information may be from many points of view, it is felt that the following details may serve a useful purpose in the planning of future biological control programmes. A knowledge of what insects have already been tried and their subsequent fate must be of paramount importance in considering new projects and it is with this consideration in mind that the following data are presented.

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Order. COLLEMBOLA.

F. SMINTHURIDAE.

Sminthurus viridis Linn. (Clover Springtail or Lucerne Flea).

The Clover Springtail is believed to have reached Western Australia in 1910 (Newman 1910) per medium of baled fodder imported into the State from South Australia. Since that date it has spread rapidly through the South-West, its distribution being bounded roughly by the 15 isohyet, although the principal damage is done within the 19 in. rainfall line where the subterranean clover pastures are established.

On account of the large areas involved, artificial control measures never offered a practical solution to the problem, so cultural and biological methods seemed the most worthy of investigation. The biological aspect of Lucerne Flea control came into evidence in 1931 when the Bdellid Mite [*Biscirus lapidarius* (Kramer)] was discovered at Waroona (Newman and Womserley 1932).

Since then, colonies have been distributed to all parts of South Western Australia where the flea is troublesome, as well as to South Australia, Victoria, New South Wales, Tasmania, and New Zealand.

The mite established itself most readily in the higher rainfall areas and for some time it appeared doubtful as to whether it would gain a footing in the comparatively dry Avon Valley districts (Newman 1934). In recent years, however, it has increased greatly in these regions, with apparently beneficial results.

An account of the biology of the mite is given by Jenkins (1935) showing that the creature passes over the summer in the egg stage. Discussing the population density of *Sminthurus* and *Biscirus*, on a small area intensively studied over a period of 2 years, Norris (1938) states "The impression was gained in the field that *Sminthurus* diminished in numbers at the end of the season long before the meteorological conditions were sufficiently adverse to account for the fall whilst *Halotydeus*, though even more suseeptible to conditions of drought and high temperatures was still present in large numbers. It seems possible that the Bdellid was at least partly responsible for this early decline."

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Order. HEMIPTERA.

F. **PENTATOMIDAE.**

Nezara viridula (Linn.) (Green Tomato Bug.)

This introduced bug was first reported within the State at Bunbury in 1920. Since then, it gradually spread throughout the lower South West to become a serious vegetable pest. Artificial control measures have never proved very satisfactory owing to the robust nature of the insect, and several experiments with parasite introductions have been made.

The first attempt at biological control was made in 1932 when Newman obtained from the Florida Agricultural Experimental Station, two consignments of a tachinid fly (*Trichopoda pennipes* F.). In both instances no living material survived the journey.

In 1933 from Dr. Priesner of Egypt, Newman obtained a few rafts of bug eggs parasitised by the Scelionid *Microphanurus basalis* Woll. and from the 30 wasps which emerged, a nucleus colony was formed (Newman 1934).

During 1934 about 1,000 wasps were distributed and parasitised material was regained in the field. The wasp carried over the winter as an adult in the laboratory and survived successfully in the field as parasitised material was obtained from several localities in the spring of 1935.

In 1935, 30,000 and in 1936, 20,000 parasites were distributed and the insect is now widely established. A marked decrease in the importance of the pest has been noted since the establishment of the Egyptian parasite.

Microphanurus has been reared from the eggs of *Oechalia consocialis* and the Pittosporum bug (*Apines geminata*) in Western Australia.

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F. JASSIDAE.

Typhlocyba froggatti Baker (Apple leafhopper).

The apple leafhopper is a native of Europe which has now become established in many apple growing countries of the world.

It was first recorded in Australia in 1918 but did not reach Western Australia until 1938 when it was reported at Bridgetown.

Artificial control measures employing nicotine sulphate and D.D.T. have proved very satisfactory but an attempt to establish a wasp parasite was considered justified. *Anagrus armatus* Ashm. was successfully introduced from New Zealand by Dr. J. Evans of the Tasmanian Department of Agriculture and parasitised overwintering eggs were obtained from this source in 1943.

The wasps were liberated at Bridgetown in October, 1943, but so far there is no evidence of their having become established. Arrangements are in hand for further introductons to be carried out.

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F. APHIDIDAE.

Brevicoryne brassicae Linn. (Cabbage Aphis).

Several attempts have been made to control cabbage aphis biologically and, although complete success has not been attained, the pest has been greatly reduced. The chief controlling factor is recorded as being a hymenopterous parasite obtained from Ceylon, twenty four having been originally introduced by George Compere in 1907 (Robinson 1908). Two Coccinellids and two hymenopterous parasites (one possibly being *Diaeretus rapæ* Curt.) were also introduced by Compere from Eastern Australia in 1902 (Compere 1902 and Anon 1906). *Orcus chalybeus* Bd. became established, but O. *lafartei* Mls. did not survive. Lea (1897) referred to the Cabbage Aphis as the "worst enemy that the cabbage has." Newman (1934) says "the position is greatly improved by the introduction of parasites from the Orient."

So far it has not been possible to check the identity of the hymenoptera involved.

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Eriosoma lanigera. Hausm. (Woolly Aphis).

When this aphis reached Western Australia is not definitely known, but as early as 1895 (Lea 1895) it was recorded as "widely distributed throughout Western Australia and one of the most serious pests which the apple grower has to contend with." The suppression of the aphis by the wasp *Aphelinus mali* Hans. is one of the most outstanding local achievments in biological control. The parasite was introduced into the state in 1923 from New Zealand with the co-operation of Dr. Tillyard of the Cawthron Institute. The first experiments were carried out in an orchard at Guildford and subsequently the insect was distributed to orchardists throughout the South West. Before the introduction of *Aphelinus* several routine spray treatments failed to control the Woolly Aphis in the principal apple growing districts whereas now, artificial treatments for the pest are seldom necessary.

Lady-birds (*Leis conformis*) also plays a part in the control of this pest and the first colony was introduced into the State from Tasmania as early as 1896 by Claude Fuller (Breen 1906 and Despeissis 1901). Further introductions were made by Lea in 1901 (Anon 1901A) and Hooper in 1902.

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Toxoptera aurantii. Fons. (Black Orange Aphis).

Although no economic control has been obtained, the Woolly Aphis parasite (*Aphelinus mali* Hans.) has been reared from *T. aurantii*.

Unspecified species of hymenoptera were introdueed by Compere from Algeria in 1906 and from Ceylon in 1907 and 1909 against "Black aphis" presumably *T. aurantii*. The parasites failed to become established.

Macrosiphum rosae Rcaum (Rose aphis.)

Compere forwarded some unspecified species of syrphids from the Philippine Islands in 1907 to combat this aphis, but the predators failed to establish.

Aphididae (unspecifi d.)

Compere, Lea, and Fuller introduced a number of aphis parasites and predators concerning which little aceurate detail is available.

Table I shows what is known of these introductions:—

TABLE I.

Parasite or Predator.	Introduced From.	Introduced By.	Date Introduced.	Where Liberated.	Number Liberated.	Subsequent History.
Coccinellid	Marseilles	Compere	1904	Metropolitan Area	....	Established
Coccinella californica Man.	California	do.	1906	do.	328	Failed
Rhizobius sp.	Queensland and New South Wales	do.	1902	do.	....	?
Hippodamia convergens Guer.	California	do.	1906	do.	471	Failed
Coccinellid	Italy	do.	1906	do.	22	do.
Do.	India	do.	1906	do.	65	do.
Do.	Algeria	do.	1907	do.	8	do.
Verania lineola Fabr.	Eastern Australia	do.	1902	do.	....	do.
Scymnodes lividigaster Nuls.	do. do.	do.	1902	do.	....	do.
Syrphid flies	Malaga (Spain)	do.	1902	do.	....	do.
Do.	do.	do.	1903	Guildford	2	?
Do.	Colombo	do.	1907	Metropolitan Area	10	?
Do.	Philippine Islands....	do.	1909	do.	50	?
Coccinella septempunctata L.	Mediterranean	do.	1903	do.	....	Failed
Hymenoptera	Algiers	do.	1906	do.	....	do.
Orcus bilunulatus .... (Anon 1901A)	Tasmania	Lea	1901	Swan	....	?
Haylzia mellyii (Anon 1901A)	do.	do.	1901	?	....	?
Coccinellid	Colombo	Compere	1907	Metropolitan Area	25	Failed
Do.	do.	do.	1907	do.	?	do.
Do.	India	do.	1907	do.	50	....
Do. 4 spp.	do.	do.	1907	Metropolitan Area and Goldfields (Kalgoorlie?) and Burracoppin	430	?
Unspecified (Despeissis, 1906)	Queensland	do.	1902	Metropolitan Area	5	?
Do. do.	N.S.W.	do.	1902	Perth and Bunbury	40	?
Do. do.	Seville	do.	1903	Metropolitan Area	4	?
Do. do.	do.	do.	1903	do.	56	?
Do. do.	Algiers	do.	1906	do.	2	?

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F. COCCIDAE.

Saissetia oleae (Bern.) (Olive Seale)

This almost cosmopolitan pest has been established in Western Australia for many years. In fact, Lea (1895) suggested that it was an indigenous species, although there appear to be no authentic grounds for this assumption.

For many years, Olive or Black Scale was one of the most serious pests of local orchards (Newman 1909), but successful parasite introductions have greatly reduced the toll taken by this insect.

Several species of parasites have been experimented with over the past 50 years but the three which have proved most successful are *Scutellista cyanea* Mot. *Metaphycus loundsburyi* How. and *Tomocera californica* How.

The results of the recent trials with *Metaphycus helvolus* Comp. must not be taken as conclusive as only a small colony was procured from the C.S.I.R. and satisfactory host material was not available in sufficient quantity to breed a second generation.

Table II indicates the various attempts at insect introduction which have been made in past years :—

TABLE II.

Parasite or Predator.	Introduced From.	Date of Introduction.	Number Introduced.	Number Liberated.	Where Liberated.	Introduced By.	Subsequent History.
Red scutellista	China	1905	3	?	?	Compere	Failed
Do. do.	Timor	1905	....	3	Metropolitan Area	do.	do.
Scutellista cyanea Motsch	Brazil	1904	60	?	?	do.	do.
Do. do.	California	1904	19	19	Metropolitan Area	do.	Established
Do. do.	Capetown	1902	30	30	do.	T. Hooper	Failed
Do. do.	do.	1903	85	85	do.	do.	do.
Do. do.	do.	1902	?	11	Perth and Coolup	Compere	?
Do. do.	California	1903	?	90	Various	do.	Established
Metaphycus loundsburyi How.	Capetown	1902	?	?	Metropolitan Area	T. Hooper	do.
Microterys sp.	do.	1902	?	?	do.	do.	Failed
Do.	do.	1902	?	20	do.	Compere	do.
Tomocera californica How.	N.S.W.	1902	?	45	?	do.	Established
Quaylea whittieri (Girault) = *Hymencyrtus crawi* Ashm. (Essig., 1931A)	do.	1902	?	11	Metropolitan Area.	do.	Failed
**Myiocnema comperei* Ashm.	Queensland....	1902	?	938	51 colonies, various	do.	Established
Aristolochia sp.	Hong Kong....	1903	?	12	Metropolitan Area	do.	Failed
Rhizobius centralis Ericks	Eastern Australia	1902	?	?	do.	do.	Established
Metaphycus helvolus Comp.	Canberra (C.S.I.R.)	1943	No liberations made	?	....	Jenkins	....
Unnamed	Eastern Australia	1903	?	60	....	Compere	?
Do.	South Africa	1903	?	85	....	do.	?
Do.	Brazil	1904	?	60	....	do.	?
Do.	California	1904	?	19	....	do.	?
Do.	Canton	1903	?	10	Metropolitan Area	Compere	?
Do.	Hong Kong....	1903	?	12	do.	do.	?
Do.	Capetown	1903	?	83	Various	do.	?
Do.	do.	1903	?	17	Metropolitan	do.	?

*Now considered to be a possible secondary parasite (Essig., 1931B).

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Aonidiella aurantii (Mask.) (Red Scale)

Red Scale was first reported on citrus in Western Australia from the Metropolitan Area by Lea in 1895. Since that date, it has gradually spread to most of the citrus growing districts of the State.

Various attempts to control this scale biologically have been made and a number of Coccinellids as well as wasp parasites have been introduced. The most successful introduction is the hymenopteron *Aphytis chrysomphali* Mercet. imported by Compere from China in 1905.

The most recent introductions have been made with the co-operation of the Entomological Division of the C.S.I.R., the wasp having been originally obtained from China by the Imperial Parasite Service, Canada.

Comperiella bifasciata How. has long been known as a parasite of the Yellow Scale [*A. citrina* (Coq.)] but it is only in recent years that a race has been detected capable of developing in *A. aurantii*.

In Table III details of the various attempted introductions are set out :—

TABLE III.

Parasite or Predator.	Introduced From.	Date of Introduction.	Number Introduced.	Number Liberated.	Where Liberated.	Introduced. By.	Subsequent History
Coccinellid	China	1905	?	14	Metropolitan Area	Compere	Established
Do.	Jerusalem	1904	?	160	do.	do.	Failed?
Do.	Japan	1907	?	?	do.	do.	Failed
Do.	Ceylon	1907	?	?	do.	do.	do.
Do.	Spain	1907	?	?	do.	do.	do.
Aphytis chrysomphali (Mercet)	China	1905	?	?	do.	do.	Established
Unspecified parasite (Hymenoptera?)	Japan	1907	?	20	do.	do.	?
Do. do.	Colombo	1907	?	50	do.	do.	?
Do. do.	China	1907	?	20	do.	do.	?
7 spp.	do.	1907	?	?	?	do.	Failed
2 spp.	Ceylon	1907	?	?	?	do.	do.
6 spp.	Japan	1909	?	1120	?	do.	?
Comperiella bifasciata How.	Japan	1909	?	?	?	do.	Failed
Do. do.	Canberra (C.S.I.R.)	1943–44	400	1000	Harvey, Sawyers Valley, Gosnells, Metropolitan Area	Jenkins	?

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Aonidiella perniciosus (Comst.) (San Jose Scale)

The above pest was first recorded in Western Australia in 1897 (Despeissis 1897 and Fuller 1897). Its presence was so much dreaded that very stringent control measures were at once adopted and infested trees were grubbed and burned.

Attempts at parasite establishment have been made, two introductions from Pennsylvania being reported (Newman 1915). Unfortunately no living material reached this State and the species concerned is not mentioned. Two attempts to introduce hymenoptera from California in 1907 also failed. An unnamed ladybird forwarded by Compere from Spain was liberated (Anon. 1903), but with no better results than the other attempts listed.

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Aspidiotus sp.

Compere in 1902 introduced a coccinellid *Chilocorus circumdatus* Shon. from Hong Kong. Releases were made in the metropolitan area but without success. In 1903 a batch of 350 coccinellids imported from Seville were also liberated in the Perth area, but were not known to become established.

Coccus hesperidum L. (Soft Brown Scale).

This scale first appeared in local literature in 1894 (Anon. 1894) although the actual date of its introduction into Western Australia is not known. Although not a major pest, it has a wide host range and causes orchardists some inconvenience. Attempts to control this scale biologically have not been successful, but the introductions attempted are itemised in Table IV.

TABLE IV.

Parasite or Predator.	Introduced From.	Date of Introduction.	Number Introduced.	Number Liberated.	Where Liberated.	Introduced By.	Subsequent History.
Scutellista sp.	Philippine Islands	1907	?	....	?	Compere	Failed
Do.	Colombo	1907	?	16	?	do.	do.
Coccophagus lycimnia Walk.	California	1907	?	1500	?	do.	do.
Unnamed parasites (? hymenoptera)	do.	1907	?	?	....	do.	Failed to breed out
Do. do.	N.S.W. and Queensland	1902	83	?	Metropolitan Area	do.	Failed
Do. do.	China	1905	81	?	?	do.	do.
Do. do.	Algiers	1906	....	....	....	do.	All died
Do. do.	China	1905	....	....	....	do.	do.
Do. do.	Ceylon	1907	....	16	Metropolitan Area	do.	?
Scutellista, sp.	Ceylon	1908	....	....	do.	do.	?
?	Italy and Egypt	1908	....	....	....	....	?
Scutellista and others	China and India	1909	....	....	....	Compere	?

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Newman, L. J. 1909, " Beneficial Parasites," *Ibid.* Vol. XVIII, p. 381.

Lecanium sp.

In 1909 Compere introduced a Red Scutellista from the Philippine Islands, but it failed to become acclimatised.

Lecanium persicae F. (Vine Scale)

This introduced coccid was first recorded from Perth in 1901. Several parasite introductions have been made and a considerable degree of biological control has been achieved.

The wasp *Aphycus timberlakei* Ishii was introduced from California by George Compere in 1907 and is now well established throughout the South-West.

Four other unidentified species, one from Italy (Anon. 1903), two from France (Despeissis 1906) and one from California were introduced, but without success.

Coccophagus lecani Walk. was also introduced in 1907 from California and 1,500 were released in the metropolitan area, but failed to become established.

Myiocnema comperei Ash. was introduced by Compere in 1902 and, although established, is of doubtful value (Essig, 1931).

LITERATURE.

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Pseudococcus Spp. (Mealy Bugs)

In 1902, Compere introduced colonies of *Cryptolaemus montrouzieri* Muls. from New South Wales and Queensland and some 1,300 were liberated in the Metropolitan Area. The ladybird is now firmly established and is an important factor in Mealy Bug control.

LITERATURE.

Compere, G. 1902, " Introduction of Parasites," *Journ. Dept. Agric. W. Aust.* Vol. VI., p. 238.

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Order. COLEOPTERA

F. BRUCHIDAE.

Bruchus pisorum Linn. (Pea Weevil).

The pea weevil was first recorded in Western Australia in 1931 (Newman 1932). It is widely distributed in the major pea-growing districts of the South-

West and is a serious menace to the industry. The first attempted biological control was made in 1939 when, through the co-operation of the C.S.I.R., the wasp *Triaspis thoracicus* Curt. was introduced from France.

Approximately 1,000 parasites were reared and liberated at the following localities: Burges Siding, Seabrook, Wooroloo and Muresk. Field recoveries were made from peas harvested the same season at Wooroloo but although peas were planted on that site for two successive seasons no further recoveries were made either there or elsewhere.

In 1942 parasitised bean weevil eggs (*B. obtectus*) were obtained from the U.S.D.A. Bur. Ent. and Plant Quarantine, and further attempts were made to rear *Triaspis*. These were unsuccessful, however, and further introductions were prevented by war conditions.

LITERATURE.

Newman, L. J. 1932, *Journ. Dept. Agric. W. Aust.* 2nd. Ser. Vol. IX., p. 297.

Order. DIPTERA.

F. **TRYPETIDAE.**

Ceratitis capitata Wied. (Mediterranean Fruit Fly.)

The first record of Fruit fly in Western Australia came from Claremont in 1895. The following year it was found in Perth and by 1897 it had spread to Guildford. These appear to be the first records for the Commonwealth, as N.S.W. did not report the fly until 1898.

This insect is the most serious fruit pest established in Western Australia and strenuous efforts have been made to bring about its subjection by the introduction of parasites. Unfortunately, however, all attempts at biological control have met with absolute failure. The parasites from which the best results were expected were :—

Syntomosphyrum indicum Silv. and *Diachasma tryoni* Com. These wasps and also *Tetrastichus giffardianus* Silv. were reared in large numbers in cages and liberated in the field, but not in a single case was parasitised material obtained as a result of these liberations.

Table V summarises the attempts so far made to control fruit fly by biological means :—

TABLE V.

Parasite or Predator.	Introduced From.	Date of Introduction.	Number Introduced.	Number Liberated.	Where Liberated.	Introduced By.	Subsequent History.
Staphylinid (*Huamerocera brasiliensis*) (Essig., 1931)	Brazil	1904	?	?	Metropolitan Area	Compere	Failed
Hymenoptera	do.	1904	?	?	do.	do.	do.
Syntomosphyrum indicum Silv.	India	1908	?	250,000	Guildford	do.	do.
Hymenoptera	do.	1908	?	?	Metropolitan Area.	do.	do.
Diachasma tryoni Com.	Queensland....	1909	?	5,000	Guildford	do.	do.
Tetrastichus giffardianus Silv.	Fiji	1936	50 parasitised pupae	20,000	Metropolitan Area and Darling Range	Newman	do.

As seen from the table, the last parasite tested was *Tetrastichus giffardianus*, obtained from Fiji through the courtesy of H. W. Simmonds. Parasitised pupae were safely imported and a number of generations were reared in captivity, thin slices of orange being used to rear the host maggots. The laboratory colony was kept going until August, 1937, but the overwintering wasps, although apparently well developed, failed to emerge from the pupae and all breeding stock was lost.

LITERATURE.

Baker, C. 1908, "Fruit Fly Parasites," *Journ. Dept. Agric. W. Aust.* Vol. XVI., p. 27.
Compere, G. 1903, "In Search of Parasites," *ibid.* Vol. VIII., p. 518.
Compere, G. 1904, "The Introduction of the Fruit Fly Parasite," *ibid.* Vol. X., p. 68.
Compere, G. 1905, "Fruit Fly Parasite," *ibid.* Vol. XII, p. 6.
Despeissis, A. "Acting Director's Report," *ibid.* Vol. XIV., p. 328.
Essig, E. O. 1931, "A History of Entomology," (N.Y. MacMillan), p. 376.
Hooper, T. 1904, "Black Scale and Fruit Fly Parasites," *Journ. Dept. Agric. W. Aust.* Vol. X., p. 172.
Newman, L. J. 1908, "The Fruit Fly Parasite," *ibid.* Vol. XVII, p. 561.
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Newman, L. J. 1924, *ibid. Bull.*, p. 122.

F. MUSCIDAE.

Musca domestica Linn. (House Fly)

The only record of any attempt at the biological control of houseflies appears in the Annual Report of the Department of Agriculture and Industries of Western Australia for 1911. (Newman 1911.) Sarcophagid parasites said to control houseflies and blowflies were introduced from Hawaii, where they had been received from Japan. No details are available as to the technique adopted in handling these flies but the insect failed to become established.

LITERATURE.

Newman, L. J. 1911, *Ann. Rept. Dept. Agric. and Ind. W. Aust.*, p. 29.

Siphona exigua (de Meij.) (Buffalo Fly)

The Buffalo fly is believed to have reached Australia about 1825 when the first buffaloes were introduced on to Melville Island. In 1838 they were taken to the mainland and with them, the fly. The possibilities of biological control were discussed by Handschin (1932) and a summary of the life history of *Spalangia* spp. was given.

The parasite thought to be most promising was *S. sundaica* Graham from Java. A special strain of this species was tested by the Council for Scientific and Industrial Research and in March, 1933, a consignment of parasitised pupae were forwarded from Brock's Creek to Twaddle, Government Veterinary Officer stationed at Derby. From 640 parasitised pupae received, a number of wasps were bred and 60 were liberated at Yeeda Station on cattle faeces in a permanent cattle camp. The remainder were kept to breed up further supplies for distribution. In May, further sendings (approximately 3,000 pupae) were received from Brock's Creek and further releases of flies were made. In June

more releases were made and in July, Twaddle (unpublished report 1933) writes " approximately 1,900 wasps have been released in the Derby District—Meda Station 1,300 ; Yeeda, 600 to date. On 16th June I released 500 wasps on Roebuck Plains Station, Broome, on the cattle camp at Equire Well. Approximately 300 of this lot of parasites were bred at Derby, the remainder being obtained from Brock's Creek during the month of May."

In July, 1933, Twaddle writes :—

" Owing to the difficulty of breeding buffalo fly pupae at Derby for infection, the further release of these parasites is suspended for the time being."

No published information is available concerning the fate of *Spalangia* but Mr. Twaddle informed me that when he left the district in 1935 there was no sign of the wasp being active and that at no time had it given any signs of permanently establishing itself.

LITERATURE.

Handschin, E. 1932, *Coun. Sci. Ind. Res. Aust. Pamph.* 31.

F. **CALLIPHORIDAE.**

(Blowflies)

Three parasites have been tested in Western Australia for the purpose of controlling blowflies. In 1927 Newman obtained a consignment of 500 wasps (*Alysia manducator* Panz.) from Sir Guy Marshall, England, but none were reared for distribution.

In 1929 with the assistance of Dr. Miller of the Cawthron Institute an attempt was made to introduce specimens from New Zealand, but again without success. Experiments with a local wasp (*Stenoterys fulvoventralis* Dodd), were conducted for a number of years (Newman and Andrewartha 1930) but although many thousands were artificially reared and distributed, no success was obtained.

In 1915 *Mormoniella vitripennis* Wlk. = (*Nasonia brevicornis* Ashm.) was introduced from N.S.W. but without success (Newman 1915).

LITERATURE.

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Order. LEPIDOPTERA.

F. **PLUTELLIDAE.**

Plutella maculipennis Curtis. (Diamond-backed Cabbage Moth)

It is not known when this pest first gained a footing in Western Australia but it must have been amongst the first introductions as it appears in local literatures as far back as 1897 (Lea 1897). Unpublished records show that several attempts have been made to establish parasites and all available details are included in Table VI.

TABLE VI.

Parasite or Predator.	Introduced From.	Date of Introduction.	Number Introduced.	Number Liberated.	Where Liberated.	Introduced By.	Subsequent History.
Hymenopteron (*Hymenosbosmina rapi* (Cam.))?	Eastern Australia	1902	....	110	Metropolitan Area	Compere	Established
Do. do.	do. do.	1902	....	12	do.	do.	....
? Larval parasites	Malaga	1903	....	24	do.	do.	....
? Hymenopteron	Colombo	1907	....	35	do.	do.	....
Do.	India	1907	....	100	do.	do.	....
Do.	China	1909	....	110	do.	do.	....

It is now considered that the hymenopteron established in 1902 is referable to *Hymenosbosmina rapi* (Cameron). Although this parasite is often very active it does not entirely remove the necessity for artificial control measures.

Additional parasites reared from moth larvae in this state include an undetermined pteromalid and a chalcid believed to be *Chaleis vietoriae* (Girault).

LITERATURE.

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Hardy, J. E. 1938, " *Plutella maculipennis* Curt., Its Natural and Biological Control in England " *Bull. Ent. Res.* Vol. 29, p. 343.

Lea, A. M. 1897, *Journ. Bur. Agric. W. Aust.* Vol. IV., p. 1419.

Newman, L. J. 1907, " Report of Assist. Entomologist," *Journ. Dept. Agric. W. Aust.* Vol. XV, p. 916.

F. PYRALIDAE.

Hellula undalis Fr. (Turnip Moth)

This moth, like the cabbage moth, was a very early introduction into the State as it was well established by 1897 (Lea 1897).

An unidentified species of braconid was introduced from India by Compere in 1907, but it failed to become established.

LITERATURE.

Lea, A. M. 1897, *Journ. Bur. Agric. W. Aust.* Vol. IV., p. 1419.

F. GELECHIDAE.

Gnorimoschema operculella (Zell.) (Potato Moth)

This world-wide pest first figures in local literature in 1895 (Lea 1895).

It is a major pest both of growing crops and stored tubers. One attempt only at biological control has been made in this State, the wasp *Bracon gelechiae* Ashm. having been obtained from the C.S.I.R. in March, 1944. Approximately 300 wasps were liberated on a potato crop at Harvey and no further work has yet been possible on this problem.

LITERATURE.

Lea, A. M. 1895, *Journ. Bur. Agric. W. Aust.* Vol. II., p. 533.

F. PIERIDAE.

Pieris rapae (Linn.) (Cabbage Butterfly)

The cabbage butterfly was first recorded in Western Australia in January, 1943, and its rapid spread soon indicated it serious potentialities as a vegetable pest.

In December, 1943, twelve butterfly pupae parasitised by the wasp *Pteromalus puparum* Lynn, were obtained from Dr. Evans of Tasmania, who had successfully introduced the insect from New Zealand. 14,000 of this European wasp were reared and liberated the first season, colonies being sent to country and metropolitan districts. The wasp was successfully carried over the winter and a further 40,000 wasps were liberated in the summer of 1944-45 and approximately a similar number in the 1945-46 season.

Although it is somowhat early to make a definite pronouncement on the sueeess of the introduction, the fact that parasitised material has been collected from localities as far apart as Kalamunda and Albany shows that there is every prospect of *Pteromalus* becoming permanently established.

Native parasites found to be attaeking this butterfly are *Chalcis ruskini ?* Girault ; *Tricholyga sorbillans ?* (Wiedemann).

LITERATURE.

Jenkins, C. F. H. 1943, " The Cabbage Butterfly " *Journ. Dept. Agric. W. Aust.* Vol. XX, 2nd Ser. p. 35.

THE INTRODUCTION OF VERTEBRATES FOR INSECT CONTROL.

Attempts to utilise various of the higher animals for insect control have been made from time to time and as early as 1897 Helms suggested the acelimatisation of the Mole (*Talpa europaea*). The Hedgehog (*Erinaceus europaeus*) ; the Shrew (*Sorex vulgaris*) and the Toad (*Bufo bufo*). Fortunately his suggestions were not acted upon and the only actual attempt to acclimatise any of the higher animals for the purpose of pest control was made in 1933 when speeimens of the Asiatie Cattle Egret (*Bubulcus ibis coromandus*) were imported (Anon. 1933). Twenty of these birds were obtained from London, 18 were liberated in tick infested eountry and two were retained by the Perth Zoologieal Gardens. The site ehosen for their release was the Leonard River at Kimberley Downs Station, but the birds survived scarcely more than a week, falling an easy prey to hawks and other enemies. Another bird whose introduction into the North has been suggested to combat the eattle tick is the Starling (*Sturnus vulgaris*), but no definite action has been taken and the bird is at present on the prohibited list under the Vermin Act.

LITERATURE.

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Jenkins, C. F. H. 1936 *Ibid.* 2nd Ser. Vol. XII., pp. 195, 360, 520.

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